(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 April 2002 (11.04.2002)

PCT

(10) International Publication Number
WO 02/30163 A1

(51) International Patent Classification[7]: H05F 3/04

(21) International Application Number: PCT/KR01/01579

(22) International Filing Date:
20 September 2001 (20.09.2001)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
2000/55808 22 September 2000 (22.09.2000) KR

(71) Applicant *(for all designated States except US)*: **ACE LAB. INC.** [KR/KR]; 104-15, Moonji-dong, Yusung-ku, Taejon 305-380 (KR).

(71) Applicant and
(72) Inventor: **AHN, Kang-Ho** [KR/KR]; 102-1504, Ichon Apt., 412, Ichon-dong, Yongsan-ku, Seoul 140-030 (KR).

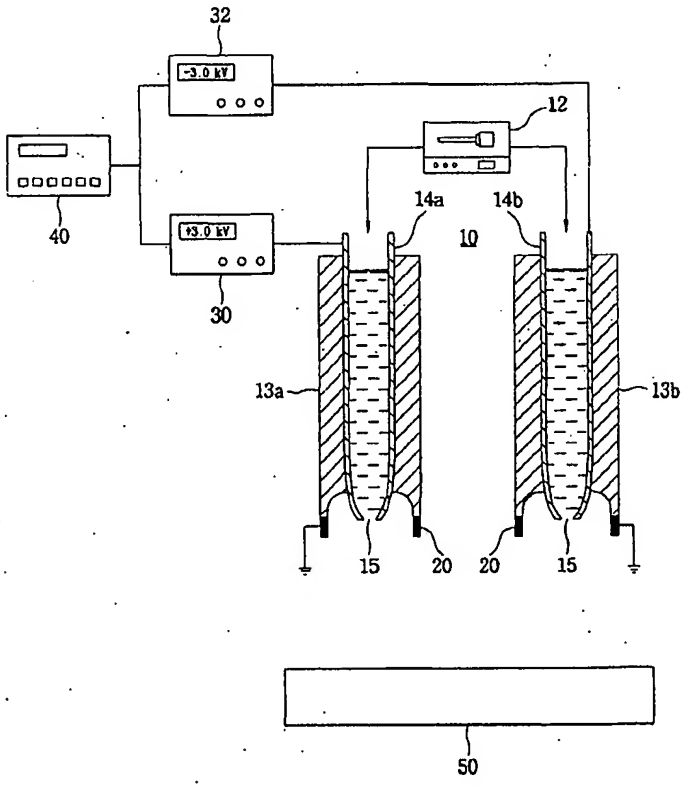
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **KIM, Kwang-Young** [KR/KR]; 210-1201, Expo Apt., 464-1, Cheonmin-dong, Yusung-ku, Taejon 305-390 (KR). **CHOI, Bong-Am** [KR/KR]; 108-1006, ChungguNare Apt., 462-4 Cheonmin-dong, Yusung-ku, Taejon 305-390 (KR). **AHN, Jin-Hong** [KR/KR]; 190-205, Mannyeon-dong, Seo-ku, Taejon 302-150 (KR).

(74) Agent: **LIM, Young-Hee**; Sinmyong Bldg., 3rd Floor, 645-21, Yoksam-dong, Kangnam-ku, Seoul 135-080 (KR).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

[Continued on next page]

(54) Title: APPARATUS FOR CONTROLLING STATIC ELECTRICITY USING ULTRA-FINE PARTICLES



(57) Abstract: Provided is an apparatus for controlling static electricity. The apparatus uses ultra-fine particles with positive polarity and utra-fine particles with negative polarity. The apparatus comprises one or more capillary for spraying liquid supplied from a liquid supply. A high voltage generator with positive polarity and a high voltage generator with negative polarity are connected to the capillary. Also, a ground electrode is spaced apart from the capillary to form an electric field in cooperation with the high voltage generators. The static electricity is easily controlled by the ultra-fine particles with positive polarity and the ultr-fine particles with negative polarity.

WO 02/30163 A1

APPARATUS FOR CONTROLLING STATIC ELECTRICITY USING ULTRA-FINE PARTICLES

Technical Field

The present invention relates to an apparatus for controlling static electricity, and more particularly, to an apparatus for controlling static electricity using highly charged ultra-fine particles with positive and negative polarities, which are generated by Electro-Hydrodynamic Atomization (EHDA) or Electrospraying.

Background Art

In general, corona discharge has been currently applied to a conventional apparatus for controlling static electricity by ionizing air. The apparatus using the corona discharge causes the air around the apparatus to pass through a corona discharge area so that the air is charged. Accordingly, the static electricity is controllably neutralized by increasing the electrical conductivity of the air. Air is generally a nonconductor of electricity through which the electricity cannot flow. However, if the air is ionized through the corona discharge so that ion density thereof is increased, the electrical conductivity of the air is also increased. By virtue of such an increase in the electrical conductivity of the air, the static electricity accumulated on the specific object can leak through the air. Herein, since the apparatus for controlling the static electricity using such corona discharge is a well-known technique, the detailed explanation of the constitution and operation thereof will be omitted.

Meanwhile, the study of the EHDA or Electrospraying has been carried out for a long time. In recent years, public interest has been concentrated on ultra-fine particles and study of the ultra-fine particles has been actively performed. An electro-hydrodynamic atomizer generates highly charged ultra-fine particles from a tip of a capillary by applying high voltage to the capillary with a spray solution contained therein and creating an electric field having a high voltage difference between the capillary and an electrode plate disposed to be spaced apart therefrom.

However, although the conventional apparatus for controlling the static electricity using the corona discharge has some advantages in that its installation and operation are simple, it still has several disadvantages or problems. First, in the apparatus for controlling the static electricity using the corona discharge, a high voltage of 5 kV or higher should be applied to corona discharge electrodes. Thus, there is a problem in that the electrodes corrode and wear away due to any sputtering phenomenon, collisions of fine particles present at the corona discharge area by any electromagnetic induction thereof, and the like. This problem causes an ultra-clean room such as a semiconductor fabrication line to be contaminated by the particles.

Second, since ozone is generated upon high voltage discharge, and fine particles, which will not be filtered out even through a general ultralow penetration airfilter (ULPA), are deposited on, accumulated on and scattered again from surfaces of the discharge electrodes, contamination by the particles is produced. Thus, there is a disadvantage in that the discharge electrodes should be periodically cleaned or exchanged,

Third, there is a remarkable difference between the positive and negative electrodes when the particles are deposited and accumulated on the discharge electrodes. The ion density may be greatly unbalanced due to such a remarkable difference. Thus, the static electricity may be much more aggravated as compared with a case where the apparatus for controlling the static electricity is not installed.

Moreover, if the static electricity is excessively generated or the ion density is to be increased depending on the environments, a very high voltage of 10 kV or higher should be applied. Thus, the above problems will be doubled.

Disclosure of Invention

Therefore, the present invention is contemplated to solve the above problems of the aforementioned prior arts. An object of the present invention is to provide an apparatus for controlling static electricity using ultra-fine particles, wherein the static electricity is easily controlled and its control efficiency is

improved by using the highly charged ultra-fine particles.

Another object of the present invention is to provide an apparatus for controlling static electricity using ultra-fine particles, wherein no ozone which is harmful to the human body and is adversely affected to processes applicable to the apparatus is generated.

A further object of the present invention is to provide an apparatus for controlling static electricity using ultra-fine particles, wherein there is neither corrosion and wear of electrodes nor contamination by the thus generated particles.

In order to achieve the above objects, an apparatus for controlling static electricity using ultra-fine particles according to the present invention comprises one or more capillaries connected to a liquid supply for allowing the particles to be sprayed and discharged from tips thereof, high voltage generating means connected to the capillaries for applying high voltages thereto, and including first high voltage generator for applying positive voltage and second high voltage generator for applying negative voltages, to generate highly charged ultra-fine particles, one or more ground electrodes disposed to be spaced apart from the capillaries by a predetermined distance for creating an electric field in cooperation with the high voltage generating means, and a control means connected with the first and second high voltage generators for controlling the voltages applied to the capillaries.

Brief Description of Drawings

FIG. 1 is a view showing the constitution of an embodiment of an apparatus for controlling static electricity using ultra-fine particles according to the present invention.

FIG. 2 is an enlarged view of a portion of the apparatus shown in FIG. 1, for illustrating how highly charged ultra-fine particles with positive and negative polarities are generated and the static electricity is controlled by means of the particles in the apparatus for controlling the static electricity using the ultra-fine particles according to the present invention.

FIG. 3 is a view showing the constitution of another embodiment of an

apparatus for controlling static electricity using ultra-fine particles according to the present invention.

FIGS. 4a to 4c are graphs for showing various waveforms of positive and negative voltages applied to the apparatus for controlling the static electricity using the ultra-fine particles according to the present invention.

Best Mode for Carrying Out the Invention

Hereinafter, embodiments of an apparatus for controlling static electricity using ultra-fine particles according to the present invention will be explained in detail with reference to the accompanying drawings.

FIGS. 1 and 2 show the constitution of a first embodiment of an apparatus for controlling static electricity using ultra-fine particles according to the present invention. Referring to FIGS. 1 and 2, the apparatus for controlling the static electricity according to the present invention includes an electro-hydrodynamic atomizer 10 for generating highly charged ultra-fine particles with positive and negative polarities. The electro-hydrodynamic atomizer 10 includes a syringe pump 12 for allowing a liquid such as water or NaCl solution to be supplied while regulating its flow rate, and two capillaries 14a, 14b to which the liquid is supplied from the syringe pump 12 and which are securely mounted within hollow cylinders 13a, 13b, respectively. Although the syringe pump 12 has been employed in the present embodiment, other known liquid supply may be used as the pump, and the capillaries 14a, 14b may be substituted for containers with orifices. A nozzle 15 for allowing the ultra-fine particles to be created and then sprayed is formed at a lower end of each of the capillaries 14a, 14b, and a ground electrode 20 is positioned at a lower end of each of the hollow cylinders 13a, 13b. Although the cylindrical ground electrode 20 is positioned at the lower end of each of the hollow cylinders 13a, 13b in the present embodiment, the ground electrode may merely be spaced apart from the nozzle 15 by a predetermined distance to create an electric field in cooperation with high voltage generators. Therefore, the ground electrode may take various shapes such as flat and perforated plates.

Furthermore, the capillary 14a is connected with a first high voltage generator 30 for applying high positive voltage to the capillary, while the capillary 14b is connected with a second high voltage generator 32 for applying high negative voltage to the capillary. The first and second high voltage generators 30, 32 are connected with a controller 40 for controlling the voltages applied to the capillaries 14a, 14b. When the high positive or negative voltage is applied between the liquid sprayed from the nozzle 15 and the ground electrode 20, a strong electric field is created between the ground electrode 20 and the liquid at a tip of the nozzle 15. Further, the shape of liquid droplets formed at the tip of the nozzle 15 varies depending on the intensity of the applied electric field. As shown in FIG. 2, the ultra-fine particles are generated while the liquid droplets take a conical shape at a constant voltage area and are changed to a cone-jet mode (where a jet is shot out) at the peak of the cone. At this time, the generated particles are much highly charged. The highly charged ultra-fine particles with positive polarity are sprayed from the nozzle 15 of the capillary 14a, while the highly charged ultra-fine particles with negative polarity are sprayed from the nozzle 15 of the capillary 14b. A target object 50, on which the static electricity should be controlled, is positioned below the nozzle 15. In order to rapidly move the ultra-fine particles created from the nozzle 15, a blower (not shown) may be disposed above the capillaries 14a, 14b, if necessary.

Next, a second embodiment of an apparatus for controlling static electricity using ultra-fine particles according to the present invention will be explained with reference to FIG. 3. In the embodiment shown in FIG. 3, the apparatus for controlling the static electricity includes a single capillary 14. A nozzle 15 for allowing the ultra-fine particles to be sprayed similarly to the constitution of the aforementioned the first embodiment is formed at a lower end of the capillary 14, and a ground electrode 20 is positioned at a lower end of a hollow cylinder 13. The capillary 14 is connected with both first and second high voltage generators 30, 32 for applying high positive and negative voltages, respectively. The high voltage generators 30, 32 are connected with a controller 40.

FIGS. 4a to 4c show various waveforms of voltages applied to the capillaries 14, 14a, 14b by the operation of the first and second high voltage generators 30, 32 and the controller 40. FIG. 4a shows a waveform of voltage in a state where the positive and negative voltages are simultaneously applied; FIG. 4b shows a waveform of voltage in a state where the positive and negative voltages are alternately applied; and FIG. 4c shows a waveform of voltage in a state where the positive and negative voltages are alternately applied during T_1 and T_3 respectively, with predetermined pause intervals corresponding to periods of time T_2, T_4. The periods of time shown in FIG. 4b during which the voltage is applied and the periods of time T_1, T_3, T_2, and T_4 shown in FIG. 4c can be independently regulated by the controller 40. In addition to the above waveforms, various waveforms of voltages may be applied to the capillaries.

In particular, the waveform of voltage shown in FIG. 4a may be applied when two or more capillaries are used. At this time, the ultra-fine particles with positive polarity are created and then discharged from the capillary 14a, while the ultra-fine particles with negative polarity are created and then discharged from the capillary 14b. When a single capillary is used, the positive and negative voltages are alternately applied as shown in FIGS. 4b and 4c. At this time, the positive voltage is applied to the capillary 14 during a predetermined period of time so that the ultra-fine particles with positive polarity are discharged from the capillary 14. Thereafter, the negative voltage is applied to the capillary 14 during a predetermined period of time so that the ultra-fine particles with negative polarity are discharged from the capillary 14.

Hereinafter, the operation of the apparatus for controlling the static electricity using the ultra-fine particles according to the present invention constructed as such will be explained.

The generation of the ultra-fine particles by the electro-hydrodynamic atomizer 10 of the embodiment shown in FIG. 1 will be explained. The high positive and negative voltages shown in FIG. 4a are applied to the capillaries 14a, 14b by the first and second high voltage generators 30, 32, respectively. Then,

strong electric potential difference (between positive and negative voltages) is generated between the ground electrode 20 and the surface of the liquid at the nozzle 15. At this time, the balance between the surface tension of the liquid and the electrostatic force is broken on the surface of the liquid, and the surface of the liquid is consequently broken. Then, the ultra-fine liquid particles with positive polarity are discharged from the nozzle 15 of the capillary 14a, while the ultra-fine liquid particles with negative polarity are discharged from the nozzle 15 of the capillary 14b. The particles created as such are extremely fine in the order of about several nanometers to several tens of nanometers. In addition, the particles are highly charged with positive and negative polarities so that their quantity of electric charge reaches the Rayleigh charge limit. Since the highly charged ultra-fine particles tends to carry out Brown motion, they do not move along their stream line but perform random motion, so that they are diffused to the air while moving downwardly.

Thus, since the positive and negative ultra-fine particles to be diffused downwardly to the air become higher in density, the electrical conductivity of the air becomes higher. Thus, the static electricity generated on the surface of the target object 50 which is positioned in a space where the electrical conductivity of the air has become higher is leaked or neutralized through the air. Accordingly, the static electricity on the surface of the object is completely removed.

In the meantime, since the operation of the apparatus for controlling the static electricity according to the embodiment shown in FIG. 3 can be easily understood by the skilled in the art from the operating description of the apparatus for controlling the static electricity according to the embodiment shown in FIG. 1, the detailed description of the operation associated with FIG. 3 will be omitted.

In the above embodiments, if water is used as the solution for creating the ultra-fine particles, the ultra-fine particles serve to carry out a further humidifying action. In such a case, therefore, there is an advantage in that the apparatus for controlling the static electricity according to the present invention carries out the humidifying action as well as the static electricity control action, in a case where the

water is used as the solution.

Although the invention has been described with respect to the preferred embodiment, the scope of protection sought in the present invention is not limited thereto. It will be understood by the skilled in the art that specific design and constitution described in the preferred embodiment is one example of the present invention and that various changes and modifications may be made thereto without departing from the spirit and scope of the invention as defined in the appended claims. For example, although it has been described that the above embodiments are limited to a case where they include one or two capillaries, the number of the capillaries employed in the present invention may be three or more. In a case where two or more capillaries are used, positive and negative voltages may be alternately applied to the capillaries.

Industrial Applicability

As described above, according to the apparatus for controlling the static electricity using the ultra-fine particles according to the present invention, there is an remarkable advantage in that the static electricity can be easily removed by creating the highly charged ultra-fine particles and then diffusing them to the air to increase the electrical conductivity of the ambient air. Further, ozone, which is adversely affected to the human body or processes applicable to the apparatus, is not generated. Unlikely the prior arts, there is no corrosion and wear of the electrodes, and there is also no contamination source of particles, which are deposited on, accumulated on and scattered again from the electrodes. Further, the electrodes need not cleaned or replaced. Even at a low voltage of 5 kV or lower, the static electricity can be controlled in the present invention several times higher than the prior arts so that the static electricity can be effectively removed. Furthermore, in a case where the water is used as the solution for generating the ultra-fine particles, a further humidifying effect is provided.

The apparatus having the above constitution and advantages according to the present invention can be used wherever there is any damage due to static

electricity, for example, the human body's shock due to the static electricity, particles contamination due to the suction force of the static electricity, or breakage or performance deterioration of any mechanism due to ESD (Electrostatic Discharge). In particular, the apparatus may be used for removing the static electricity or providing a further humidifying effect during the semiconductor and liquid crystal display fabrication process.

CLAIMS

1. An apparatus for controlling static electricity using ultra-fine particles, comprising:

one or more capillaries connected to a liquid supply for allowing the particles to be sprayed and discharged from tips thereof;

high voltage generating means connected to the capillaries for applying high voltages thereto, and including first high voltage generator for applying positive voltage and second high voltage generator for applying negative voltage to generate the highly charged ultra-fine particles;

one or more ground electrodes disposed to be spaced apart from the capillaries by a predetermined distance for creating an electric field in cooperation with the high voltage generating means; and

a control means connected with the first and second high voltage generators for controlling the voltages applied to the capillaries.

2. The apparatus as claimed in claim 1, further comprising a blower for rapidly carrying the highly charged ultra-fine particles to an object on which its static electricity should be controlled.

3. The apparatus as claimed in claim 1, wherein in a case where only one capillary is used, the first and second high voltage generators are constructed to alternately apply positive and negative voltages to the capillary under control of the control means.

4. The apparatus as claimed in claim 1, wherein in a case where two capillaries are used, one capillary is connected to the first high voltage generator while the other capillary is connected to the second high voltage generator.

FIG. 1

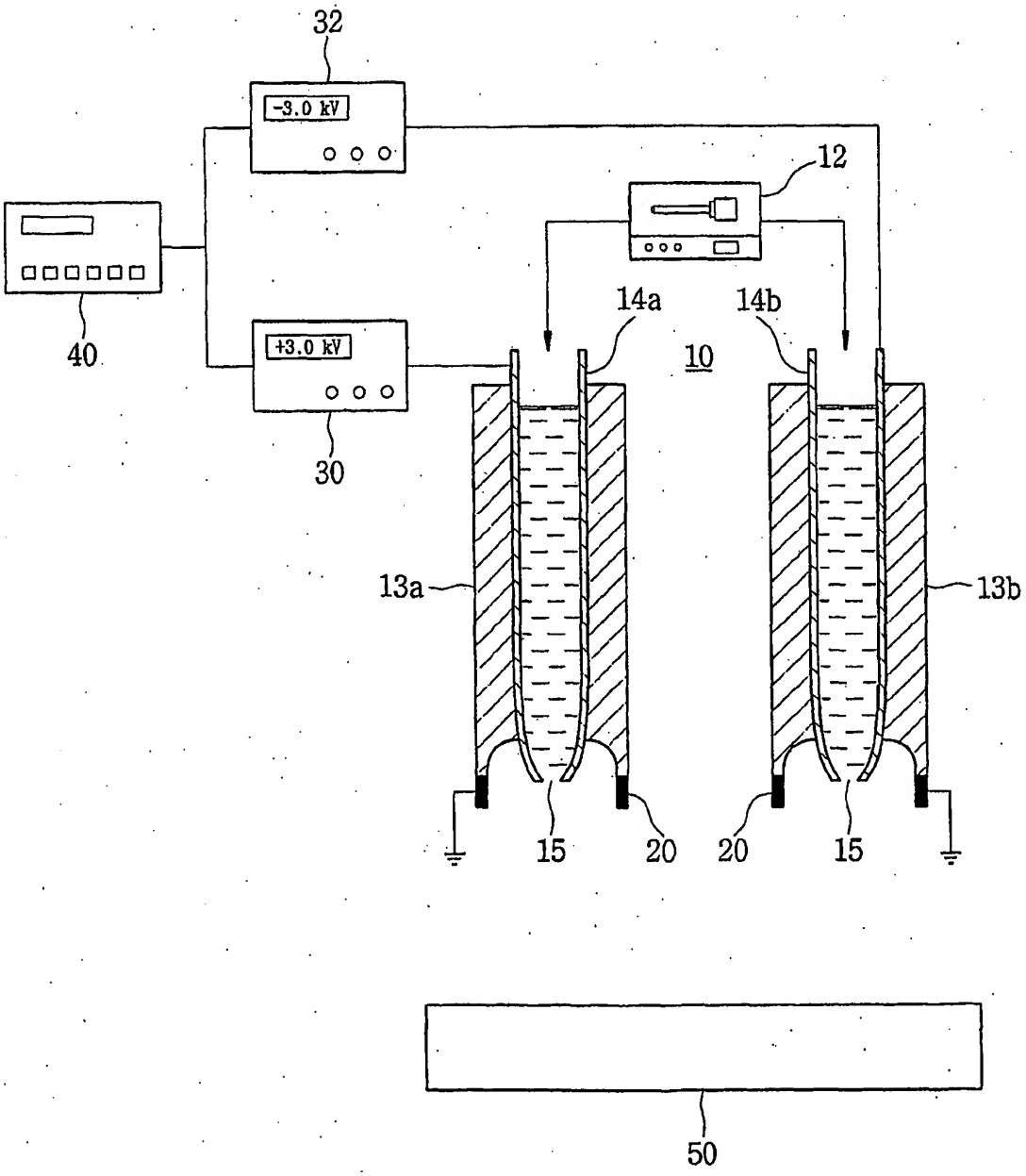


FIG. 2

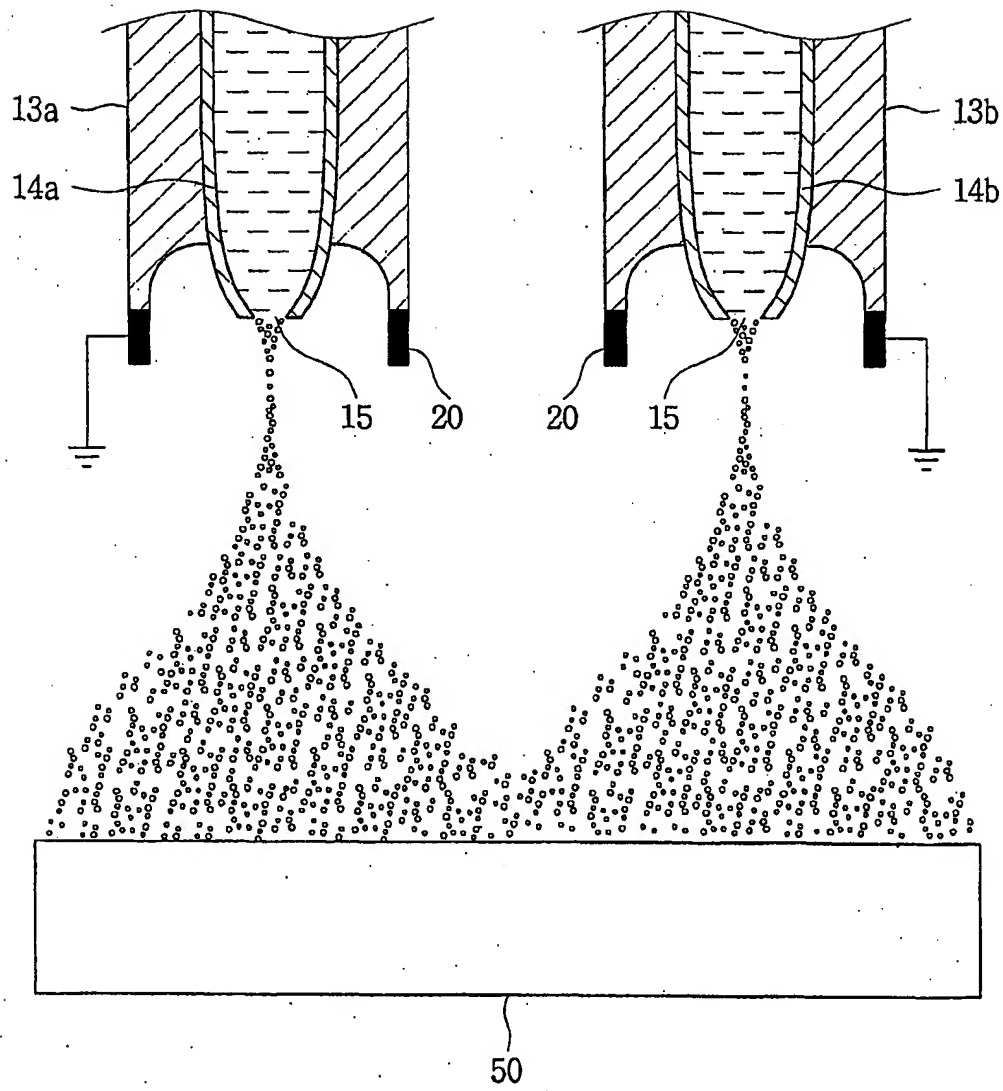


FIG. 3

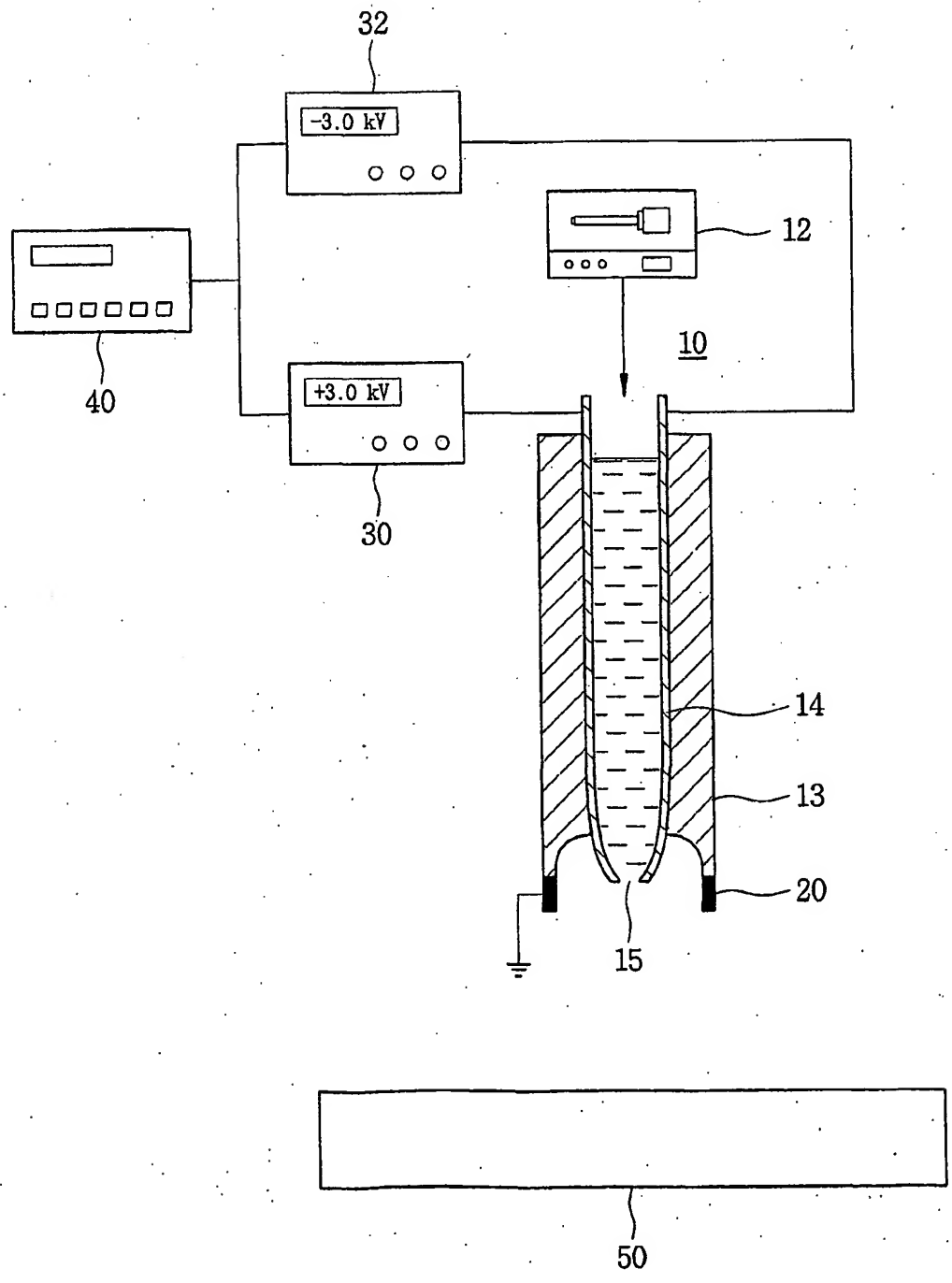


FIG. 4a

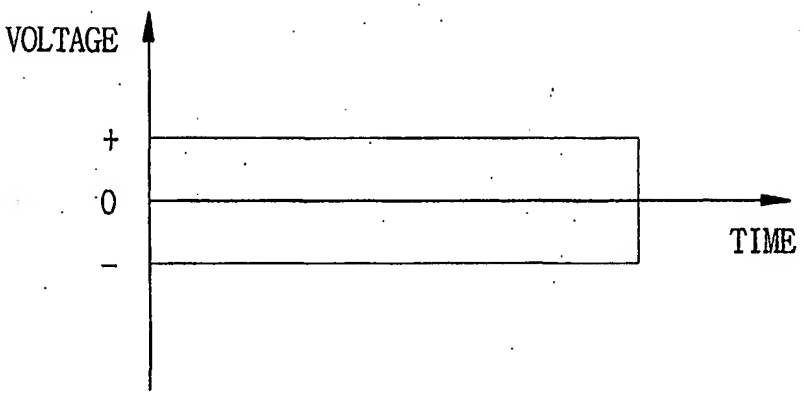


FIG. 4b

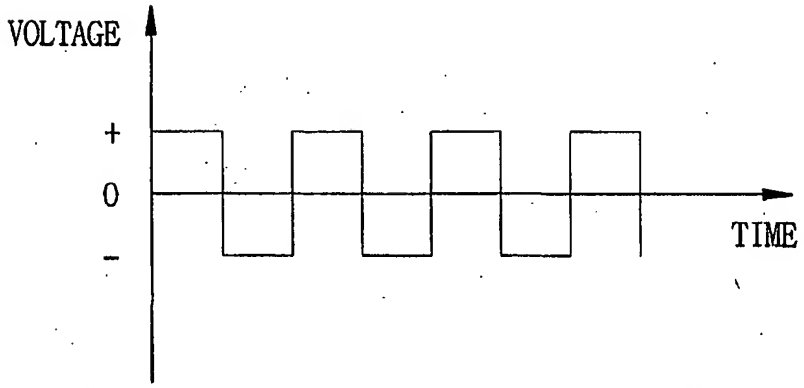
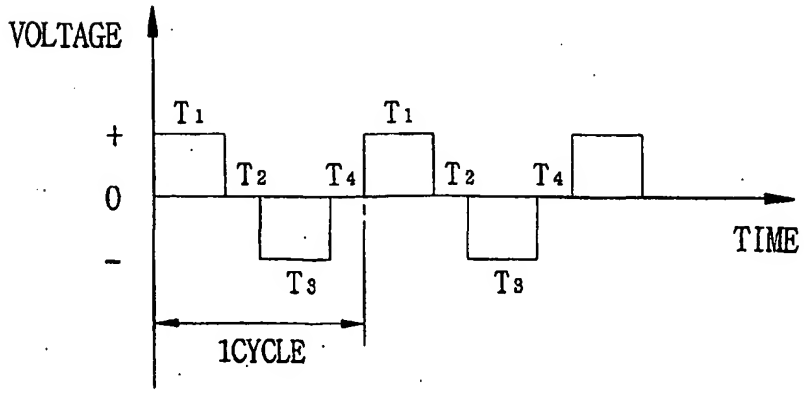


FIG. 4c



INTERNATIONAL SEARCH REPORT

ternational application No.
PCT/KR01/01579

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H05F 3/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 H05F, B05B, F03H

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applications for Inventions since 1975

Electronic data base consulted during the internationl search (name of data base and, where practicable, search trerms used)

NPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5222663 A (Imperial Chemical Industries PLC) 29 Jun 1993 See abstract and figure 1	1, 2, 3, 4
Y	US 4821508 A (GT-Devices) 18 Apr 1989 See the whole document	1, 2, 3, 4
A	US 5765761 A (Uni. of Georgia) 16 Jun 1998 See abstract and figures	1, 2, 3, 4

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevence

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 DECEMBER 2001 (24.12.2001)	26 DECEMBER 2001 (26.12.2001)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea Facsimile No. 82-42-472-7140	JEONG, Yeon Woo Telephone No. 82-42-481-5871

Form PCT/ISA/210 (second sheet) (July 1998)